TECHNICAL REPORT: NAVTRAEQUIPCEN IH-278

EVALUATION OF THE WEAPONEER MARKSMANSHIP TRAINING DEVICE (Recoil, Point-of-Aim, Power)

Physical Sciences Laboratory
Naval Training Equipment Center
Orlando, Florida 32813

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Naval Training Equipment Center
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NAVAL TRAINING EQUIPMENT CENTER

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August 1976

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Noise Level of M-16

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Complete testing of a device prior to acceptance is a necessary part of the procurement process. The Weaponeer Marksmanship Training Device was evaluated for the purpose of procurement acceptance. The tests were done from a safety point of view (acoustically and optically), and from a mechanical aspect (recoil, point-of-aim and power). This report covers the mechanical segment, and answers the question: Does the device accurately do the things

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it is supposed to do? The answer is yes, in most part. There are some minor deficiencies, but the device can perform the type of training it is meant to perform, and, more important it may actually speed up the training process.

NAVTRAEQUIPCEN IH-278

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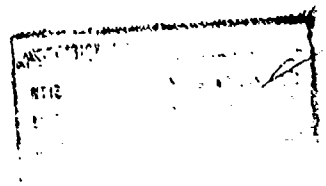

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SECTION I

INTRODUCTION

The Office of the Project Manager for Training Devices (PM TRADE), Naval Training Equipment Center, Orlando, Florida, requested an evaluation of marksmanship, operational, power and recoil parameters of the Weaponeer Marksmanship Training Device at the manufacturing plant; Spartanics in Rolling Meadows, Illinois. This evaluation was conducted on 29 and 30 June 1976.

SECTION II

STATEMENT OF THE PROBLEM

The Weaponeer Marksmanship Trainer has been developed to permit a person to learn how to hold, aim, and fire a rifle in an accurate manner. The device permits continual improvement by reviewing firing area with instructor controls.

This report evaluates this device for accuracy and realism.

SECTION III

PROCEDURE

Prior to the testing of the trainer, a set of equipment was designed to measure recoil. Then a series of tests were conducted using a standard M-16 firing live rounds at the Firing Range Facility at the Naval Training Equipment Center (NAVTRAEQUIPCEN), Orlando, Florida. Measurements were taken of rifle movement by using three different restraining methods; (1) no spring, (2) a 122 pounds/inch compression spring, and (3) tension, spring. The rifle recoil velocity was also recorded and measured for the different methods used. Acoustic measurements were taken firing live ammunition.

The same equipment used to test the M-16 live round recoil was taken to the contractor's plant to measure recoil of the simulator.

TEST INSTRUMENTATION: A recoil measuring device was designed to be capable of making a comparative measurement of recoil between a M-16 in a training device and a M-16 firing live rounds. Basically, it is a portable pendulum that suspends the rifle at four points. Three types of measurements were taken of recoil of the M-16 with live rounds and in the training device. A cylindrical helical spring of rectangular cross section, with a spring constant of 122 pounds/in. was positioned at the butt end. The amount of spring compression was measured when the rifle was fired. A tension spring was then used in place of the compression spring. The amount of extension of the spring was measured. All springs were removed and the distance the rifle butt moved was measured.

The velocity of recoil movement was measured using two photo diodes 3/4 inches apart, attached to a General Radio 1192-B counter as a timer, and a Hewlett Packard 6217A power supply to power lights and amplifier. A steel rod in contact with the rifle butt passed between the light sources and the photo diode. The amount of time the rod took to pass two accurately spaced positions was recorded on the counter. Figure 1 displays the test stand and instrumentation used. Figure 2 shows the detailed device and circuitry.

Photos were taken with a Polaroid 440. Acoustic measurements were made with a General Radio impact noise analyzer 1556-B and a Sound Level meter 1551C.

A portable rifle vise was used to restrain the rifle during accuracy tests.

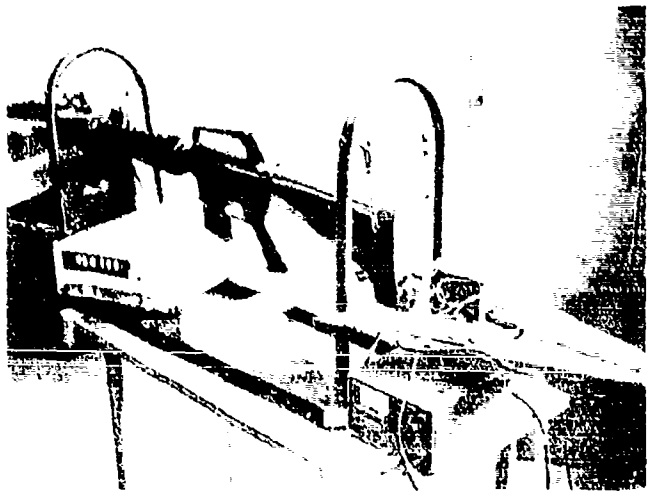


Figure 1. Test Stand and Instrumentation

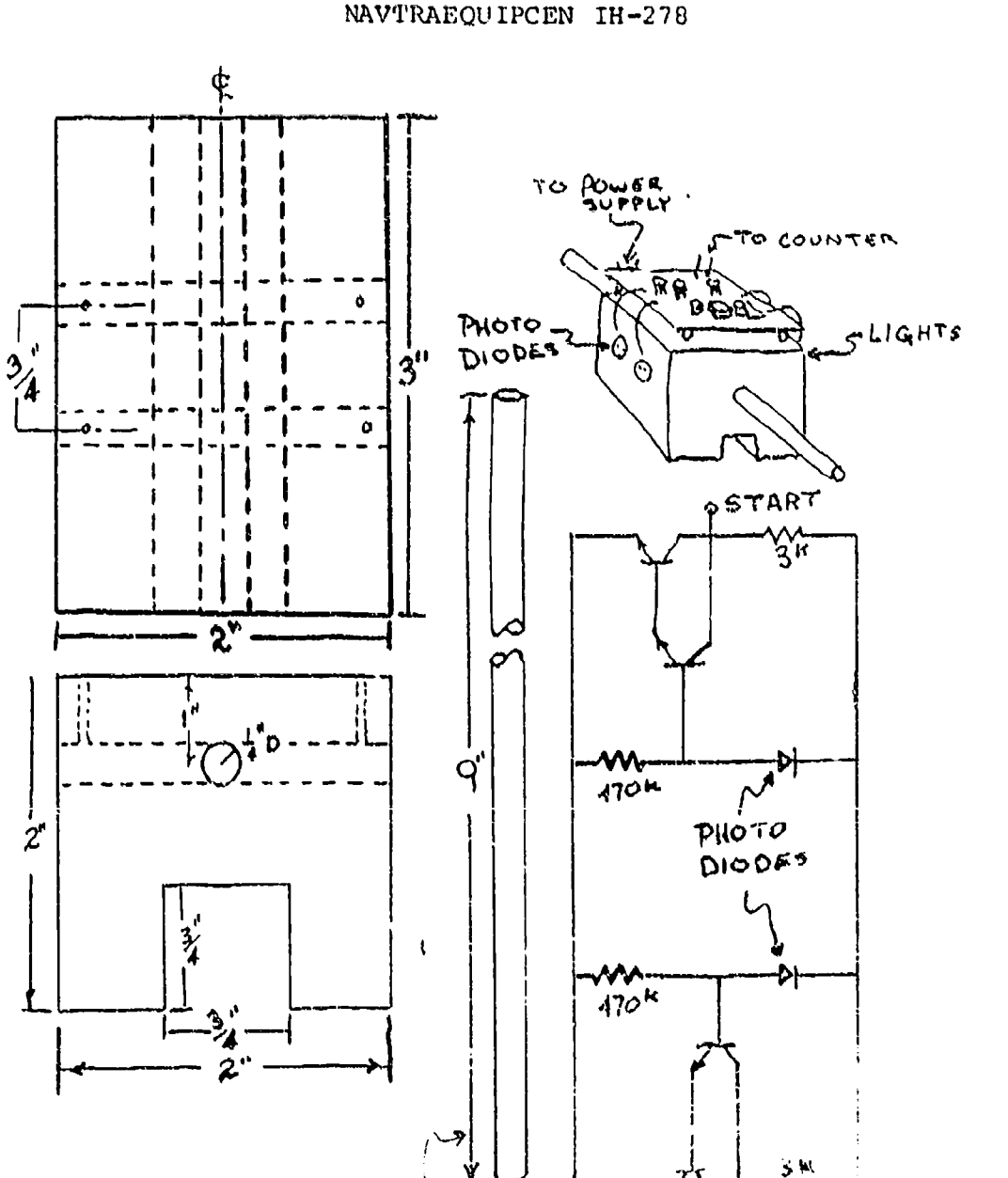


Figure 2. Device and Circuit for Measurements

TEST SPECIFICATIONS: All tests were performed under prevailing on-site conditions. No special environmental controls were required. Tests were conducted within an air conditioned building.

TEST I. MOUNTING AND ALIGNMENT

1. SCOPE

The purpose of this test is to verify that the alignment and mounting tolerances incorporated into the Weaponeer trainer accurately and realistically simulate firing with service ammunition, and that the target-weapon interface characteristics are as described in the unsolicited proposal.

2. PROCEDURE

a. Visually inspect the device. Insure that the following capabilities/functions are incorporated into the trainer;

(1) One Canadian bullseye target scaled to simulate a 25 meter range.

(2) One "F" type silhouette target scaled to simulate a 75 meter range.

(3) Visual, electronic display scope approximately 9 inches on the diagonal capable of viewing by both coach and trainee. Display scope will incorporate playback capabilities of both targets described in paragraphs (1) and (2). The scope must provide an electronic trace (transient) of the firer's point of aim prior to the first shot, a round-by-round shot pattern fired in sequence, and the capability of displaying all shots simultaneously.

(4) Printer capable of printing 1 to 30 shots and the target engaged.

(5) All necessary controls for the execution of the above functions including a control for raising and lowering the 75 meter target and a coach's override which allows all activity to continue with the exception of firing when the trigger mechanism is depressed.

b. In the prone firing position, place the weapon in a vice or M-16 slide (bench rest), aligning rifle and M-16 telescope (mounted) with the Canadian bullseye target.

c. In the single-shot mode, fire ten rounds, observing the simulated strike of the projectile on the CRT. Compare the printout results with the visual display on the CRT to insure that the shot pattern is the same. Compare the CRT, printout, and digital scoring counter to insure that all three score the

same number of hits. Insure that the digital round counter accurately records number of rounds fired.

d. Align telescope to upper left corner of bullseye (edge-shot).

e. Repeat procedure c.

f. Without disturbing the position of the weapon, lower the silhouette target.

g. Repeat procedure c. Insure that no score is recorded on the printout or digital scoring counter.

h. Align telescope to lower right corner of silhouette target (edge-shot).

i. Repeat procedure c. with stationary target.

j. Align telescope off the silhouette target. 'Point of aim is mid-way on a line drawn diagonally from the right edge of silhouette head to the right edge of the silhouette shoulder).

k. Repeat procedure c. Insure that no score is indicated on the CRT, or recorded on the printout and digital scoring counter.

l. Execute magazine changing drill. Repeat procedure c. in rapid-fire mode firing 10 shots.

m. Insure the device enables the firer to assume the prone, kneeling, sitting, and standing positions as described in FM 23-9 (No additional firing is required during the conduct of this test procedure.)

n. Fire 100 rounds with the device set on full recoil. Reposition weapon in the M-16 slide, aligning telescope as described in procedure b.

o. Repeat procedure c. insuring that the weapon and IR reflector have not become misaligned as a result of firing the device in the full recoil mode.

p. Attempt to fire weapon with coach's override activated. Insure that the weapon does not fire when the trigger is depressed.

3. FAILURES

One or more major deficiencies will constitute a failure. All deficiencies are to be corrected prior to delivery and installation. Major deficiencies are defined as follows:

a. Failure of CRT, printout, and digital scorer to score all rounds fired on Canadian, bullseye zero, and "F" type silhouette target (test procedures b and f).

b. Failure to accurately count number of rounds fired in all test procedures.

c. Discrepancy in shot pattern agreement between CRT and device print-out (all test procedures).

d. Indication of scoring credit on the CRT, printout, or digital scorer when the target is lowered and not engaged (test procedure i, m, and n).

e. Failure to allow the execution of magazine changing drills (test procedure n).

f. Failure to allow firing in all standard firing positions as specified in FM 23-9 (test procedure c).

g. Failure to score (as valid hits) a minimum of 95% of shots fired at 1/3 MR on inside edge of targets (test procedures d and j).

h. Discrepancy of more than 1/3 MR in weapon sight and IR reflector alignment after firing the device on full recoil (test procedure q).

i. Failure to repress all firing activity when coach's override is activated (test procedure r).

TEST II. WEAPON RECOIL

1. SCOPE

The purpose of this test is to verify that trainer realistically simulates weapon recoil at 0, 1/2, and full energy settings and simulates sound simulation from minimum to maximum allowable DB levels as specified in the unsolicited proposal.

2. PROCEDURE

a. Recoil Simulation: Attach recoil measuring equipment to the device using a 144 lbs per inch recoil spring rate.

(1) With the device recoil setting in the 0 position, fire five rounds. Insure that no recoil is recorded.

(2) With the device recoil setting in the 1/2 position, fire ten rounds, measuring recoil for consistency. Maximum recoil should be approximately .35" in less than 50 Mili Sec.

(3) With the device recoil setting in the full recoil position, fire ten rounds, measuring recoil consistency. Maximum recoil should be approximately 1/2" displacement in less than 55 Mili Sec.

3. SOUND SIMULATION

The noise produced by the Standard M-16 firing ball ammunition will be taken. This will be compared to the noise of the training device.

TEST III. POWER SUPPLY VARIANCE

1. PURPOSE

The purpose of this test is to verify that the trainer is designed to operate from primary power source line voltage with relative insensitivity to cycle variance as specified in the unsolicited proposal.

2. PROCEDURE (Voltage Variation (10% variance)):

a. Decrease voltage input to the device from 117 to 106 vac. Repeat test procedure in paragraph 2c, Test I.

b. Increase voltage input from 117 to 128 vac. Repeat test procedure in paragraph 2c, Test I.

3. FAILURES

In accordance with MIL-T-23991E, General Specification for Military Training Devices, the trainer should function with a vac variance of ± 10%. Failure of the trainer to operate properly at power variances less than ± 08% will constitute a system failure.

SECTION IV

RESULTS

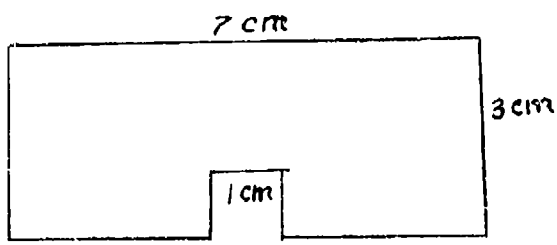
TEST I.

1. A visual inspect of the device insured the following capabilities/functions:

a. One Canadian bullseye target scaled to simulate 25 meter range (see figure 3).

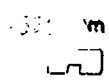
actual size for 25 meters

a



calculated reduce size for 103 inches

b



actual size of Weaponeer target

c

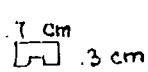
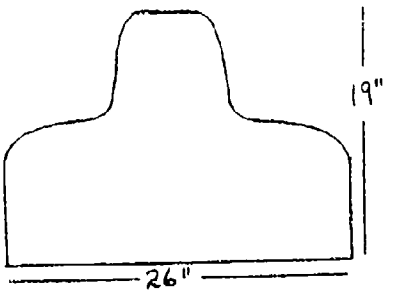


Figure 3. Canadian Bullseye Target

b. Two "F" type silhouette targets scaled (Figure 4):

actual target

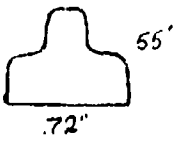
a



Weaponeer target is 103:
from front sight

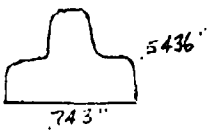
actual size of target in trainer

b



calculated for 100 yds

c



calculated for 75 meters

d

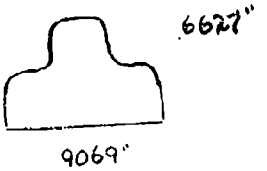


Figure 4. "F" Type Target

RESULT: The silhouette target is smaller in the device than it should be for 75 meter range simulation.

c. Visual electronic display scope is 7-7/8" in diameter. It can be viewed by both trainer and coach. Scope incorporates play-back capability for all three targets. (See Figure 5).

The scope provides an electronic trace of the trainee's point of aim prior to first shot by producing a series of dots. The round fired is indicated by a brighter point. It provides a round by round shot pattern fired in sequence, and has the capability of displaying all shots simultaneously. (See Figure 6.)

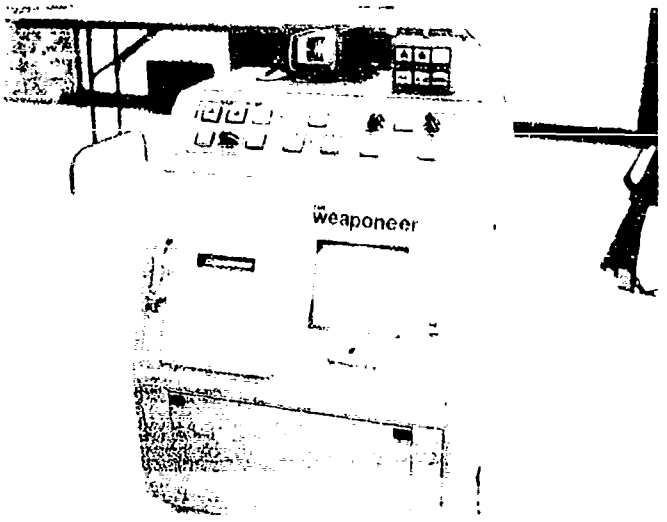
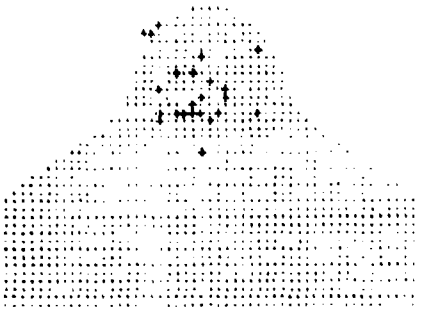


Figure 5. Display Scope



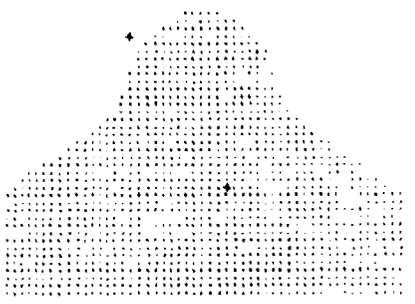
TARG 2 HITS 30 MISS 03 LATE 00

Figure 6. Score Printout

d. The device prints out the shots position on the target for 1 to 31 shots.

e. Controls for the execution of the following capability/ control:

CAPABILITY	CONTROL
Target display and playback	Target 1 button; Target 2 button; Target 3 button
Trace of point of aim	Shot one button
Round-by-round shot pattern	Each shot button
Display all shots simultaneously	Target buttons
Print 1 to 31 shots and target	Print button
Coach over-ride	Remote control box with 3 target buttons print button; clear button, and misfire button
Target control	Roll button



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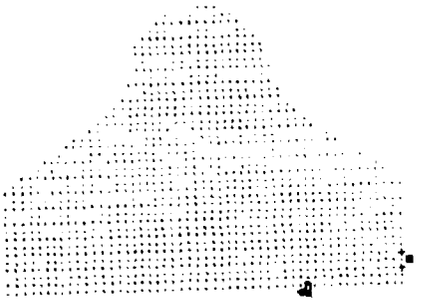

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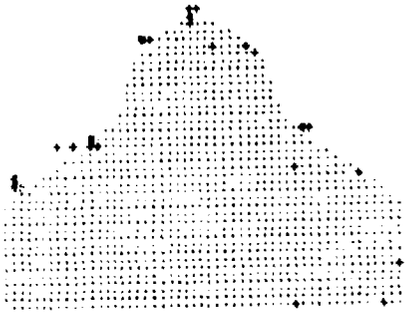

T2K 30 HITS 11 MISS 20 LATE 00

TARG 2 HITS 08 MISS 01 LATE 02

Figure 7. Scoring Displays

2. The device was set in a prone position. The rifle was secured in a vise; the telescope mounted on rifle and aligned. The Canadian bullseye target was then scored (see figure 8).

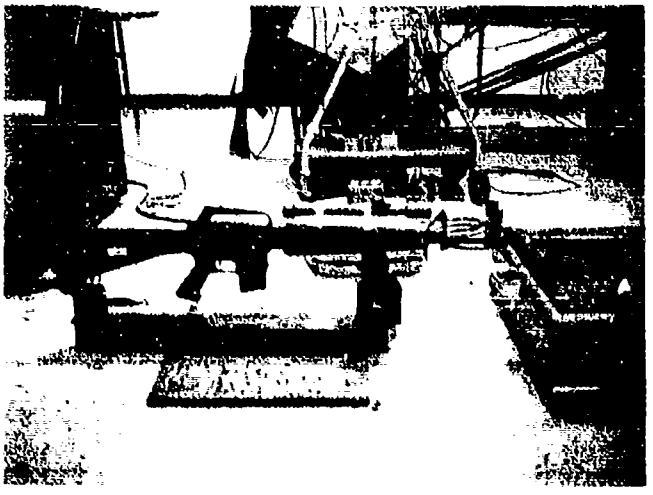

Figure 8. Rifle Mount

In the single shot mode, ten rounds were fired. All ten rounds appeared on the same spot on the CRT of the Weaponeer Trainer and the same spot on the printout. (See Figure 9). Ten rounds were displayed on the digital scoring counter (see figure 10).

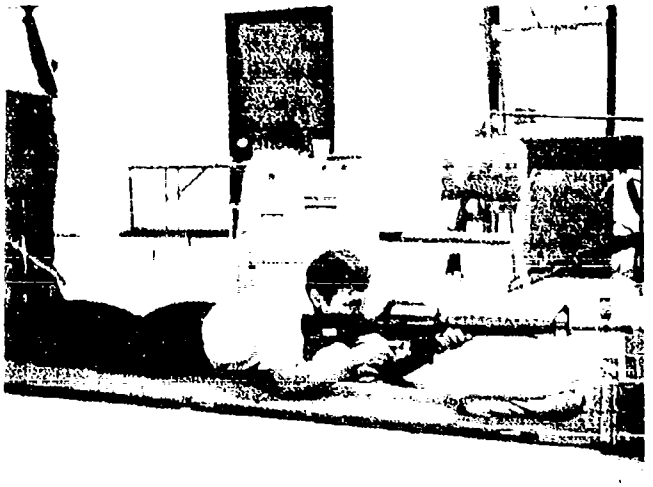

Figure 9. Weaponeer Trainer CRT

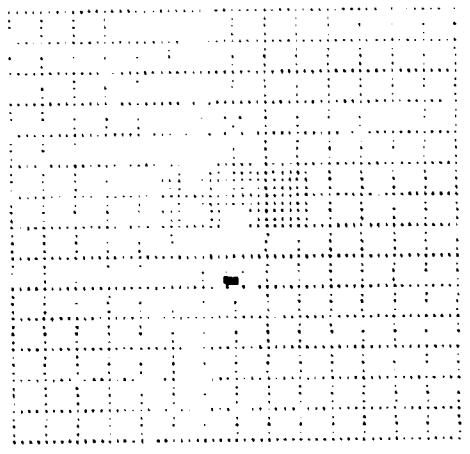

Figure 10. Shots in Lower Target

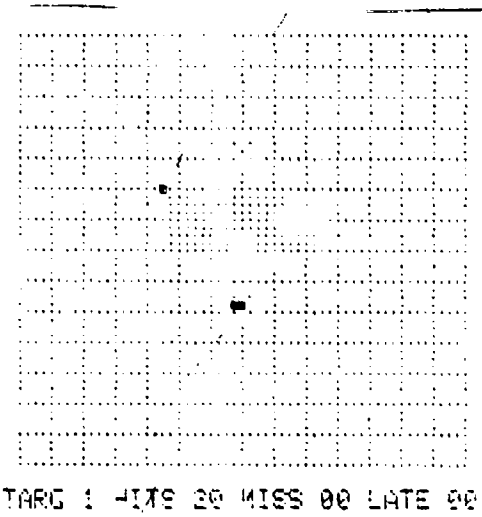

Figure 11. Shots, Upper Left Hand Corner

The telescope was aligned to the upper left corner of bulls-eye. Ten rounds were fired (see Figure 11). All hit the same spot; showed the same spot on CRT, and printed out ten more rounds.

a. The standing position and the kneeling are the same as the prone position. The device is only jacked-up or lowered down to take any position. Therefore, all firing was conducted in the prone position for convenience of solidly mounting the rifle and maintaining accuracy (see figure 12).

b. The silhouette target was lowered after one shot was fired, then 18 more shots were fired. One shot showed on the CRT and the printout. Eighteen shots were recorded as late on the digital score (see figure 13).

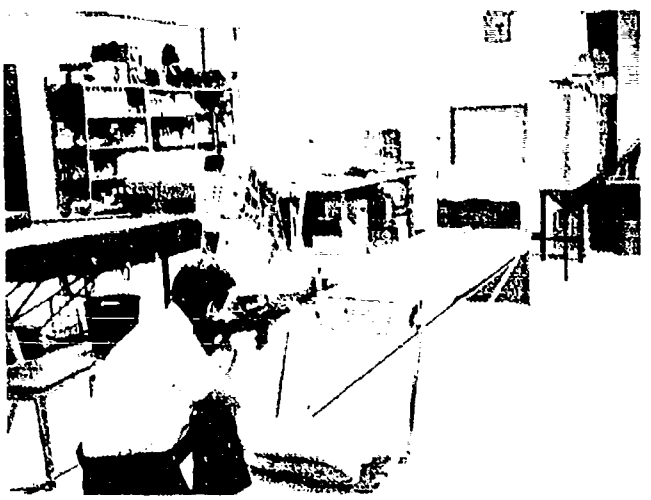

Figure 12. Kneeling Position

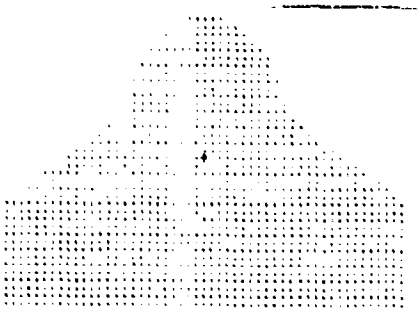

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Figure 13. Silhouette Target Response

c. Align telescope to edges of target (edge shot). Scoring was most accurate along bottom line and side edges where a shot half way on and half off the target scored a hit. Along the curved surfaces of the target the shot had to be completely on the target to score a hit (shots half on and half off did not score a hit).

d. Magazine drill was executed. The magazine was set for 10 rounds. After 10 rounds were fired, the rifle would not fire. A second 10 rounds was set on the clip. It was inserted in the rifle and 10 rounds of rapid fire was executed. The magazines and scoring system operated properly. One clip was defective and jammed after a few rounds.

e. The device enables the trainee to assume the prone, kneeling, sitting, and standing positions with approximately one minute delay between positions.

f. One hundred and twenty-four rounds were fired in full recoil. The spot was repositioned on the target and 20 rounds were fired. There was no misalignment of IR reflector or telescope. The test was conducted twice (see figures 14 and 15).

g. Many attempts were made to fire the weapon with coach's override activated. The device does not fire when the coach's misfire button is depressed.

3. FAILURES:

a. No failures of the CRT and printout to score all rounds on Canadian bullseye zero and 2 "F" type targets.

b. No failure to accurately score all rounds fired.

c. No failure in shot pattern reproduction and between CRT, printout, and digital display.

d. No scoring occurred on CRT, printout or digital score when the target was lowered.

e. Failure of one magazine during magazine changing drills. It was believed that this was a singular defect and not an error in technique, as another clip worked properly. The magazines performed properly in the drill procedures.

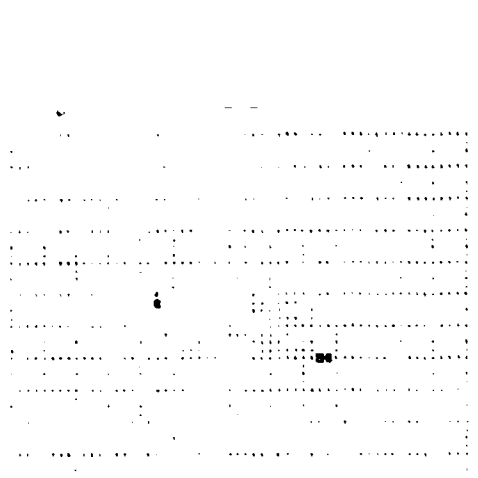

Figure 14. Aim point before 124 rounds were fired

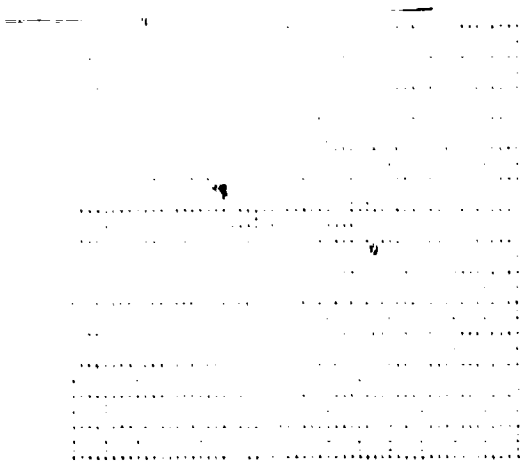

Figure 15. Aim point after 124 rounds were fired

f. No failure to allow firing in all standard firing positions.

g. No failure to score 100% of shots fired within 1/2 MR on the inside edge of the targets.

h. No failure of discrepancy of more than 1/3 MR in weapon sight and IR reflector alignment after firing the device on field recoil.

i. No failure to repress all firing activity when coach's override is activated.

TEST II.

RECOIL SIMULATION

The rifle was placed in recoil measuring equipment. Three different conditions were used during the tests: 122 psi mounted at the butt; a tension spring; and then no spring. The velocity and displacement of the rifle were measured in each case. Refer to tables 1 and 2. Table 3 contains noise level measurements taken 14 inches from the bolt.

TABLE 1. RECOIL OF M-16 RIFLE FIRING LIVE ROUNDS

	TIME MILI SEC FOR .75"	VELOCITY INCHES/ MILI SEC	DISPLACEMENT INCHES		
		122#/IN SPRING			
	13.383	.0553	.42		
	11.306	.06548	.42		
	11.813	.0627	.42		
	11.456	.065	.38		
	11.474	.0645	.40		
Average	11.886	.06269	.408	4.224	ft/ sec
		NO SPRING			
	11.175	.0662	2.50"		
	10.471	.0707	2.50"		
	12.788	.0579	2.30"		
	7.924	.09338	2.35"		
	13.180	.0561	2.35"		
Average	11.1076	.068856	2.40"	5.738	ft/ sec
		TENSION SPRING			
	21.652	.0341	2.25"		
	16.744	.0442	2.35"		
	16.764	.0441	2.35"		
Average	18.387	.0408	2.32"	3.400	ft/ sec

TABLE 2. RECOIL OF WEAPONEER TRAINER

RECOIL SETTING ON DEVICE	TIME TO TRAVEL 3/4" MILI/SEC		VELOCITY IN/MILI/ SEC	DISPLACEMENT INCHES
	122#/IN SPRING			
1(minimum)	553.0			.20
	679.2			.27
	267.69			.30
	265.21			.28
	491.36			.30
Average	451.292	.00166	.1383	.27
3	47.10			.32
	40.32			.35
	42.40			.35
	43.57			.35
Average	43.347	.017302	1.441	.343
6	37.30			.35
(Normal)	39.47			.37
	39.94			.35
	39.40			.34
	38.61			.37
Average	38.944	.019258	1.604	.356

TABLE 2. RECOIL OF WEAPONEER TRAINER (Continued)

RECOIL SETTING ON DEVICE	TIME TO TRAVEL 3/4" MILI/SEC	VELOCITY IN/MILI/ SEC	DISPLACEMENT INCHES
10 (Max)	38.21		.40
	39.31		.38
	40.45		.38
	40.73		.40
	43.54		.45
	42.15		.42
	51.93		.41
	45.63		.27
	45.63		.32
	42.71		.37
	39.87		.40
	39.36		.38
Average	42.46	.01766 in/ mili/sec	1.47 .38 ft/sec

TABLE 2. RECOIL OF WEAPONEER TRAINER (Continued)

RECOIL SETTING ON DEVICE	TIME TO TRAVEL 3/4" MILI/SEC	VELOCITY IN/MILI/ SEC	DISPLACEMENT INCHES
	TENSION SPRING		
6(Normal)	22.30		1.25
	24.28		1.12
	24.28		1.18
	24.16		1.12
	24.43		1.12
Average	23.89	.031 in/ms, 2.6 ft/sec	1.158
10(max)	24.41		
	23.18		
	23.73		1.80
	23.51		
	23.51		
	23.40		1.90
	24.21		1.59
	23.49		1.55
	22.14		
Average	23.51	.031 in/ms, 2.66 ft/sec	1.71 inches
	NO SPRING		
1 (min)	38.13		
	31.72		
	34.71		

TABLE 2. RECOIL OF WEAPONEER TRAINER (Continued)

RECOIL SETTING ON DEVICE	TIME TO TRAVEL 3/4" MILI/SEC	VELOCITY IN/MILI/ SEC	DISPLACEMENT INCHES
	NO SPRING (Cont)		
	36.07		
	33.42		
	34.89		
Average	34.82		
3	26.50		
	27.85		
	26.58		
	28.63		
	27.02		
	28.57		
	29.02		
Average	27.74		
6	22.14		
	20.86		
	20.70		
	22.25		
	20.40		
	22.02		
	21.02		
6(Normal)	19.61		2.25

TABLE 2. RECOIL OF WEAPONEER TRAINER (Continued)

RECOIL SETTING ON DEVICE	TIME TO TRAVEL 3/4" MILI/SEC	VELOCITY IN/MILI/ SEC	DISPLACEMENT INCHES
	NO SPRING (Cont)		
	20.09		2.13
	20.49		2.15
	19.63		2.15
	20.64		2.15
Average	20.82	.036 in/ms 3.00 ft/sec	2.17
8	21.41		
	21.03		
	20.67		
	21.34		
	21.08		
	21.22		
Average	21.125	.036 in/msec 2.96 ft/sec	
10 max	20.57		
	21.31		
	19.99		
	19.63		
	19.75		
	20.21		
10(max)	19.15		2.25

TABLE 2. RECOIL OF WEAPONEER TRAINER (Continued)

	RECOIL SETTING ON DEVICE	TIME TO TRAVEL 3/4" MILI/SEC		VELOCITY IN/MILI/ SEC	DISPLACEMENT INCHES
		NO SPRING (Cont)			
		18.61			2.55
		19.00			2.75
Average		19.80	.038 in/mil/sec 3. velocity at beginning of travel		3.2 ft/sec 2.35
		25.42			2.20
		23.60			2.85
		27.45			2.25
		37.14			2.30
		35.14			2.85
Average		29.75	.025 in/mil/sec 2.1 ft/sec velocity at end of travel		2.4375

TABLE 3. NOISE LEVEL OF THE M-16 LIVE ROUNDS 14 INCHES FROM BOLT

PEAK	TIME AVERAGE db	DIFFERENCES db	DECAY TIME
152.5 db	135	17.5	.09 mili sec
153.5	135	18.5	.08
151.5	133	18.5	.08
152.0	133	19	.07
152.0	134	18	.085
151.0	130	21	.05
153.5	131	22.5	.04
154.5	132	22.5	.04
152.0	129	23	.035

DEFINITIONS:

Peak = the highest level reach during the shot.

Time average is a measure of the level maintained over a period of time (In this case .05 seconds).

Decay time = time required for the wave to drop 8.7 decibels in level from its initial value.

DISCUSSION: The acoustic noise level of the M-16 is approximately 152 db at the trainees ear.

The acoustic level of the headphones of the Weaponeer trainer was reduced to a level where noise measurements could not be taken. The noise of the recoil mechanism of the device was higher than the noise produced at the headphones.

TEST III.

A test was conducted to determine if the Weapcneer Trainer could tolerate a variation of input electrical power and still operate.

The voltage was reduced to 102 vac by means of a variac for a period of 20 minutes, and the test outlined below was conducted. The voltage was increased to 130 vac, and the same test was conducted over a period of 20 minutes.

TEST: In the single shot made, ten rounds were fired and the simulated strike of the shot was observed on the CRT. The printout was compared to the visual display on the CRT to insure a similar shot pattern. Compare the CRT, printout, and digital scoring counter. Insure that the three systems indicate the same number of hit. Insure the digital round counter accurately records the number of rounds fired.

Comparison	102 Volts	130 Volts
1. Printout to Visual Display	Ok	Ok
2. CRT to Printout to Digital Source Center	Ok	Ok
3. Digital round counter to number of rounds fired	Ok	Ok

Results: Variations of power showed no effect on the operation of the trainer.

SECTION V

DISCUSSION

The Canadian target was scaled down to conform to the target as if it were at 25 meters range. This was not the case for the two silhouette targets. They should have been scaled down to 75 meters; however, they were much smaller, they were scaled to simulate approximately 100 yards. The smaller silhouette targets were necessary in order to show misses on the visual electronic display. If the larger silhouette (to conform to 75 meters) was used, it would fill up the visual electronic display and near miss would not be detectable.

The visual electronic display was 7 7/8" on the diagonal and not 9" on the diagonal as designated in the test procedure. All hits and misses were recorded on the device and visual display in their proper location. There were no false scores. The device was raised from floor lever (for prone position) to 2 feet up (to conform to kneeling position) to 4 feet above the floor (to conform to standing position). It took about 3 or 4 minutes to change positions. Scoring and operation was accurate at all positions. At one point a release catch broke during the lowering operation but was not considered serious. The release catch was repositioned so this would not happen again.

Originally the evaluation of the noise level was part of this evaluation. It was later performed by another group. However, no one was taking acoustic levels of the M-16 with live ball ammunition. Therefore, it was performed during our tests. The M-16 produced an acoustic level of 152 db. The acoustic level at the head phones of the training device had been turned down so low (for safety reasons) that it became unimportant as a noise simulator.

The M-16 fired with live rounds produced a greater velocity of recoil than the Weaponeer. However, the displacements were similar. The recoil of the M-16 feels sharper than that of the Weaponeer.

TABLE 4. SUMMARY OF DATA PRESENT IN OTHER TABLES

M-16		WEAPONEER		
VELOCITY	DISPLACEMENT	POSITION	VELOCITY	DISPLACEMENT
122#/in spring 5.2 ft/sec	.408"	6	1.6 ft/sec	.356"
		10	1.4 ft/sec	.38"
tension spring 3.4 ft/sec	2.32"	6	2.6 ft/sec	1.16"
		10	2.66 ft/sec	1.71"
no spring 5.7 ft/sec	2.40"	6	3.0 ft/sec	2.17"
		10	3.2 ft/sec	2.44"

Electrical power was varied from 102 volts to 130 volts on the Weaponeer without causing any malfunction in the equipment.

SECTION VI

CONCLUSION

The tests show some areas of the trainer performance that do not correspond to the M-16 with live rounds, i.e., noise and recoil. Other areas such as aiming and scoring performed exceptionally well. The ability to know where the trainee is aiming prior to firing can solve many training problems.

SECTION VII

RECOMMENDATIONS

The Weaponeer trainer can be used as a preliminary trainer to train people in small arms firing. The ability to trace the point of aim, play back target results and permit accurate scoring is at the forefront in the state-of-the-art in computer scoring controls.

This device would be very useful in training personnel in rifle firing.

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